Report for 2001RI2101B: Phytoremediation of Aged Aromatic Contaminants in Soil Using White Lupin

There are no reported publications resulting from this project.

Report Follows:

Background

Soils contaminated with petroleum hydrocarbons, chlorinated solvents, and their by-products pose a risk to water quality in the Northeastern U.S. Bioremediation of soils contaminated with these chemicals is often hampered by "aging" of contaminants, a process by which contaminants are sequestered into the nanopore structure of soil, rendering these compounds inaccessible to microorganisms that may degrade them (Alexander, 1999). We conducted a study to evaluate the potential for white lupin (*Lupinus albus*) to improve efficacy of bioremediation of "aged" organic contaminants in soil. Citrate is exuded in large quantities by the roots of white lupin (Gardner et al., 1983; Dinkelaker et al., 1989), and the chelation of iron in iron oxides in soil by citrate may modify the nanopore structure of soil (Gorres et al, 2000) sufficiently to release "aged" contaminants.

Experimental

Soil from the B horizon of a Bridgehampton silt loam was placed in 1-gallon pots. Naphthalene was added to all treatments at an initial concentration 100 µg per kg soil. Treatments were as follows:

I. Contaminant aged 0 weeks – Planted
II. Contaminant aged 0 weeks – Not planted
III. Contaminant aged 4 weeks – Planted
IV. Contaminant aged 4 weeks – Not planted
V. Contaminant aged 10 weeks – Planted
VI. Contaminant aged 10 weeks – Not planted

All treatments were incubated under greenhouse conditions. Four replicates of each treatment were used. Planting occurred after the aging period for a particular treatment was completed. After planting the plants were allowed to grow for 8 weeks under P-limiting conditions, at which point the soil was sampled, the naphthalene extracted from soil using methanol/acetonitrile, concentrated on a solid-phase cartridge, and the concentrated extract analyzed by HPLC with UV detection.

Results

The highest mean concentrations of naphthalene were observed after aging for 0 weeks (101 μg/kg), followed by 4 weeks (53 μg/kg) and 10 weeks (12 μg/kg) (Table 1).

Table 1. Effects of white lupin (*Lupinus albus*) on the concentration of naphthalene in soil as a function of aging time. Values shown are means (n=4).

	Naphthalene concentration (μg/kg soil) in:	
Aging time (weeks)	Unplanted	Planted
0	99.3	102.8
4	56.7	50.1
10	14.5	9.5

There appeared to be lower concentrations of naphthalene in planted mesocosms aged for 4 and 10 weeks. However, statistical analyses using a paired *t*-test indicated that there were no statistically significant differences ($P<0.05$) in soil naphthalene concentration between planted and unplanted treatments regardless of time of aging.

Discussion

The disappearance of naphthalene from mesocoms was likely due to a combination of biodegradation and volatilization, which proceeded at a rate that was similar regardless of planting. The absence of an effect of white lupin on naphthalene disappearance from "aged' contaminated soil may be a matter of timing. Contaminant aging for longer periods of time (e.g. many months to years) – as frequently happens in actual contaminated sites (e.g. Alexander, 1999) – may result in a larger fraction of the contaminant being sequestered in nanopores. This would make it easier to detect effects of lupin root exudates. In addition, effects may be more apparent if plants are grown in contaminated soil for a longer period of time. These data are being used to design a second set of experiments that will improve our ability to detect effects of white lupin bioremediation of aged naphthalene in soil.

Literature Cited

Alexander, M., "Biodegradation and Bioremediation", 2nd ed. Academic Press, San Diego (1999).

Dinkelaker, B., Romhel, V., and Marschner, H. *Plant Cell Environ*. **12,** 285-292 (1989).

Gardner, W. K., Barber, D. A., and Parbery, D. G. *Plant Soil* **70,** 110-124 (1983).

Gorres, J. H., Stolt, M. A., Amador, J.A., Schulthess, C. P., and Johnson, P.W. in

"Groundwater: Past Achievements and Future Challenges" (O. Sililo et al., eds.), pp. 755-758. Proc. XXXth Congr. Groundw., Int. Assoc. Hydrol., Capetown, South Africa (2000).